SECTION 2—ARMAMENTS AND ENERGETIC MATERIALS TECHNOLOGY

OVERVIEW

This section lists the critical technologies shown in the box above required to develop and produce in quantity safe, affordable, storable, and effective conventional munitions and weapons systems of superior operational capability, such as: Infantry and crew-served weapons systems; ammunition; artillery weapons systems; torpedoes, depth charges; bombs; land and sea mines, demolition devices; high explosive, kinetic energy and pyrotechnic warheads; projectiles; submunitions; propulsion systems; and fuzes, safing and arming devices, and their component parts. Technology related to these products is listed elsewhere in the MCTL, particularly in Sections 4, 6, 8, 12, 14 and 15. Likewise, elements of precursor munitions technology are reflected in the Materials and Equipment Annex of the MTCR, and are embedded in nuclear, and CB/BW munitions of all types. The additional technology areas of air dispersed explosives systems, missiles, non-lethal weapons, regenerative liquid propellant gun and armor and warhead defect survivability do not contain militarily critical technologies but may contain critical emerging technologies.

SECTION 2.1—AMMUNITION, SMALL AND MEDIUM CALIBER (<81 MM)

OVERVIEW

This section covers the development, production, and use of cased, combustible- or consumable-case, and telescoped ammunition; and kinetic energy projectiles for infantry and crew-served weapons, including single shot, automatic, rapid fire, guided or unguided devices. Coverage includes small and medium caliber fixed ammunition up to 60 mm; mortar rounds up to 81 mm; cannon ammunition up to 45 mm; surface-launched projectiles up to 60 mm; grenades; military shotgun shells up to 70 mm; and ammunition or related technology for infantry assault weapons. The technologies cover advanced weapons systems of the appropriate calibers, including both rapid-fire defense, anti-armor, or antipersonnel weapons; shoulder-fired recoilless rifles or missiles, including anti-armor, air defense and assault rifles.

Table 2.1-1. Ammunition, Small and Medium Caliber Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
CASE - COMBUSTIBLE	Muzzle velocities > 1400 m/sec Residue < .1%	Selected energetic materials	None identified	None	WA ML 3, 21, 22 USML III
AMMUNITION - TELESCOPED	Penetration > 2 calibers	Plastic Casing	None identified	None	WA ML 3, 21, 22 USML III
PROJECTILES - GUIDED- OR COURSE-CORRECTED WITH INTEGRATED THRUSTERS	Specific impulse > 200 sec Continuous operation > 20 s	Hydroxyl-Ammonium-Nitrate (HAN)	None identified	Fire control systems that incorporate course correction codes for rapid fire gun systems. Aiming and firing codes for accurate fire control; and interior, exterior, and terminal ballistic codes	WA ML 3, 21, 22 USML III
FIRING SYSTEMS - BULK-LOADED AND REGENERATIVE-LIQUID PROPELLANT	Muzzle velocity > 110% solid equivalent Muzzle velocity same as that achievable with equivalent solid propellant whose volume is at least 10% greater	None	None identified	Computer codes and microchips for control of rapid fire, charge/recharge of propellant	WA ML 3, 21, 22 USML III
MULTIMODE PERSONAL WEAPONS	Range > 500 m Weight < 20 lb	None	None identified	None identified	WA ML 3, 21, 22 USML III

SECTION 2.2—BOMBS, WARHEADS, AND LARGE CALIBER PROJECTILES (>81 MM)

OVERVIEW

The technology covers the critical elements of conventional, improved conventional, "precision-guided," "smart," "brilliant," or "sentient" ammunition and warhead subsystems for air-, sea-, and ground-launched systems. More specifically, the technology covers bombs, submunitions, missile warheads, and large caliber projectiles, generally > 60–81 mm. The technology is included in DoD Research and Technology Plans. None of the critical elements have application to commercial products, with the exception of shaped charge technology to oil-well penetrators.

Table 2.2-1. Bombs, Warheads, and Large Caliber Projectiles Militarily Critical Technology Parameters

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
Kinetic energy penetrators	Penetration > 400 mm Equivalent RHA at 60° arc	None identified	None identified	None identified	WA ML 3, 16, 18, 21, 22 USML XXI
Self-forging fragment (SFF)	Penetration > 100 mm Equivalent RHA < 10 standoff	None identified	Compaction and forming equipment, and process regimes, for heavy-metal liners	None identified	WA ML 3, 18, 21, 22 USML XXI
Explosively formed projectile (EFP)	Penetration > 100 mm Equivalent RHA > 200 m standoff	None identified	Compaction and forming equipment, and process regimes, for heavy-metal liners	Algorithms for sensing, fuzing and deployment	WA ML 3, 18, 21, 22 USML XXI
Shaped charges	Penetration > 8 CD	None identified	None identified	None identified	WA ML 3, 18, 21, 22 USML XXI
Tandem or multiple warhead munitions	Penetration > 400 mm Equivalent RHA at 60° arc	None identified	None identified	None identified	WA ML 3, 18, 21, 22 USML XXI

SECTION 2.3—ENERGETIC MATERIALS

OVERVIEW

These technologies cover high explosives and gun and missile propellants. They are concerned with the manufacture of ingredients and their formulation as compositions ready for incorporation into conventional munitions and weapons systems. Some energetic materials are used in WMD. Commercial explosives are used by the military during major hostilities or by military engineers for civil works.

Table 2.3-1. Energetic Materials Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
HIGH EXPLOSIVE FORMULATIONS	Any high explosive formulation with a detonation velocity > 8700 m/s or a detonation pressure > 340 kilobars or Crystal Density > 1.8 gm/cm^3 dv > 8000 m/s or dp > 250 kilobars > 250 °C for > 5 min	Not applicable	Not applicable	Not applicable	WA ML 8, 18, 21, 22 USML V
MISSILE PROPELLANT SOLID COMPOSITIONS (FOR ROCKET OR MISSILE PROPULSION SYSTEMS OR SUBSYSTEMS)	Any solid propellant with I_p (under standard conditions) > 250 s for non-metallized, or > 270 s for aluminized compositions Or I_p > 230 s for non-haloenized, and 250 s for non-metallized and 266 s for non-haloenized for compositions.	Not applicable	Not applicable	Not applicable	WA ML 8, 18, 21, 22 USML V
GUN PROPELLANTS	Any gun propellant having a force constant greater than 1200 kJ/kg (400,000 ft/lb)	Not applicable	Not applicable	Not applicable	WA ML 8, 18, 21, 22 USML V

SECTION 2.4—FUZING, SAFING, AND ARMING

OVERVIEW

This subsection addresses the development, production, and use of safing, arming, and fuzing devices for munitions/weapons systems, their subsystems, or their components. Fuze technology also draws on technologies listed in Sections 5 and 15, adapted to the various precision, weight, geometry, environment, cost, reliability, and shelf-life requirements of the munitions and weapons systems. The safing and arming requirements are derived from the need for a fuze never to set off a munition before it reaches a chosen burst point relative to a target, and then to function in the munition with better than 95 percent reliability at that point, even after decades of storage; or to remain passive under severe physical stress for substantial periods and then to function with split second timing, drawing on integrated power supplies that are themselves dependent on instant, synchronous activation. The cost requirements for high usage components are such that a few cents or even fractions of a cent per device can significantly affect the affordability or cost-effectiveness of designs. None of the systems, subsystems, materials or software are dual-use items, although some components related to navigation and control may have potential civil applications.

Table 2.4-1. Fuzing, Safing, and Arming Militarily Critical Technology Parameters

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
Multi Option Fuze for Artillery (MOFA)	Manual set time 4–199.9 sec, Precision < 0.1 sec; Inductive setting capability compatible with autoloader rate of fire of 10–12 rds/min, 4–8 simultaneous impacts; Withstand > 20,000 g and temp < 100° C, ECM hardened	Ga AS for MMIC chip	High g telemeters (PCM and other environments); soft recovery test vehicles	Computer programs for design of conformal antennae for fuze sensors; automatic target recognition; clutter modeling; signal (ECM/ECCM) processor modeling	WA ML 3, 4. 21, 22 WA Cat 3A, B,. D, E USML III, IV CCL Cat 3A, B, D, E
Electronic-time fuzes	Reliability > 95% Timing accuracy < .001 sec error	None identified	None identified	None	WA ML 3, 4, 21, 22 USML III, IV
Proximity fuzes medium altitude (100–500 m above ground level)	Detonation accuracy < 100 m CEP	None identified	None identified	None	WA ML 3, 4, 21, 22 USML III, IV
Smart mine fuzes	Remote arm and Safe Selectable target identification with a P > 80% identification accuracy	None identified	None identified	Algorithms that fuse sensing and reference to arm and detonate mine	WA ML 3, 4, 21, 22 USML III, IV
Guidance-integrated fuzes	Sensing Accuracy < 0.1 m CEP	GaAS chips	None identified	Algorithms that integrate sensing and fuzing validated data	WA ML 3, 4, 21, 22 USML III, IV

SECTION 2.5—GUN AND ARTILLERY SYSTEMS

OVERVIEW

This subsection covers the development and production of artillery weapons systems, including the subsystems and components, the propelling charges, rocket motor assists, associated interior and exterior ballistics, and the warhead interfaces. The concern is also with chemical and electrothermal-chemical propulsion systems for tube-launched projectiles of calibers greater than 81 mm. The technology has no civil applications, but generates significant commercial competition among both developed and developing countries in the sale of older (1960's), standard products, and the provision of ammunition to replenish stocks for the obsolescent weapons of Russia and NATO countries. Emerging technology is concerned with the evolution of liquid propellant propulsion systems, and with the development of autonomous fire control systems.

Table 2.5-1. Gun and Artillery Systems Militarily Critical Technology Parameters

Technology	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
Demolition devices - Multistage, Encapsulated multistage munitions, or Advanced Tandem forward charges	Probability of detection > 90% at ranges > 2 km; Data process time < 1 sec to fire	None identified	None identified	Ammunition guidance and control algorithms; validated tech. data packages	WA Cat 3, 4, 21, 22 USML III, IV
Autoloaders - advanced, modular artillery charges	Capable of autoloading and firing 10 rounds/min at muzzle velocities > 825 m/sec and ranges of 4–30 km	None identified	Propellant grain production equipment	Fire control and charge selection algorithms	WA ML 2, 21, 22 USML II

SECTION 2.6—MINES, COUNTERMINES, AND DEMOLITION SYSTEMS

OVERVIEW

This subsection covers technology for land and sea mines, and demolition systems (but not demolition charges, such as demolition "blocks," unless they are intended to be assembled components of an integrated system). The emphasis is on scatterable, precision, or "smart" devices. Included in this section are special forces and man-portable urban warfare demolition systems. Military operations in urban terrain (MOUT) items are sometimes geometrically constrained versions of shoulder-fired, antitank missiles that permit safe functioning in confined spaces. Aspects of the warhead technology are covered under Section 2.1, and the rocket motor technology is covered by Section 2.5. Elements of the technology are covered by DoD S&T Plans, and the technology is not relevant to WMD. Emerging technologies are concerned with sensor fuzed, multi-option systems that can be mass dispersed and remotely armed or disarmed. An example is the emerging airborne stand-off minefield detection system (ASTAMIDS) which will provide commanders with the ability to conduct reconnaissance, provide early obstacle and minefield detection, and communicate the locations of minefields to maneuver forces prior to their arrival.

Table 2.6-1. Mines, Countermines, and Demolitions Systems Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
SENSOR-FUZED MINES	Remotely (air or ground) settable at 5 km standoff; Effective over 360° at < 50 m target standoff, detection probability > 75% distinguishes different target signatures	None identified	None identified	Digital signal processing algorithms to identify friend or foe and track target vehicles	WA Cat 4, 21, 22 USML III, IV
DEMOLITION DEVICES - MULTISTAGE, ENCAPSULATED MULTISTAGE MUNITIONS, OR ADVANCED TANDEM FORWARD CHARGES	Hard structure penetration of > 1 m at 50 m standoff	None identified	None identified	Algorithms for sequential firing of ground-emplaced high-explosive charges and blasting agents	WA ML 3, 4, 21, 22 USML III, IV